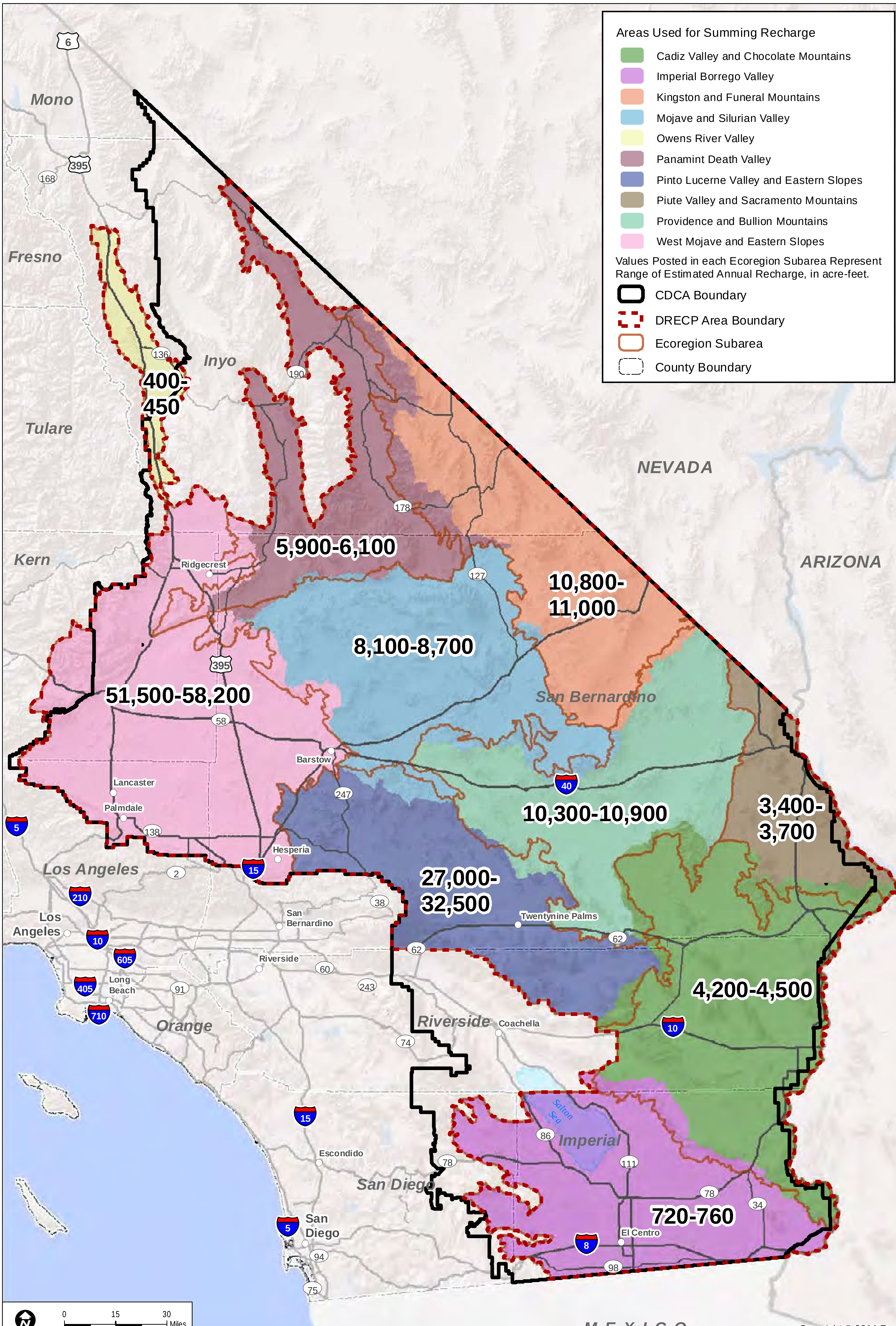

Sources: ESRI (2014); Flint and Flint (2007)

FIGURE III.6-7

Estimated Average Annual Recharge by Ecoregion Subarea Assuming 0- to 15-percent of Precipitation Runoff Becomes Recharge

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Watersheds and areas outside the overall general DRECP area boundary were not included in the recharge summation even though some of those areas may generate surface runoff and subsurface inflow that could influence DRECP area basin water budgets. For example, the simulated average recharge within the boundaries of the Owens River Valley ecoregion subarea is only 400 to 450 acre-feet per year (Figure III.6-7), which is almost 2.5 orders of magnitude less than average recharge estimated for the valley by Danskin (1998), which used detailed water budget information that included tributary inflows. However, detailed evaluations like that reported for Danskin (1998) do not exist for most of the DRECP area, and recharge to the Owens River Valley is benefited by its location adjacent to the eastern slopes of the Sierra Nevada. Runoff from these slopes most likely contributes more runoff to Owens Valley recharge than the contributions from other mountain slopes to other basins located in the DRECP area. Therefore, the recharge estimates reported in Figure III.6-7 do not represent absolute values for project-specific analyses. They are rather approximate values for making relative comparisons between ecoregion subareas.

Precipitation recharge modeling shows that in-place recharge is significant only in the mountains; recharge is negligible in valley floor areas where all infiltrated rainfall is intercepted and consumed by plants (Hogan et al. 2004). On a per-area basis, basins with small valley floor areas and relatively extensive adjacent mountainous areas receive relatively larger quantities of recharge. These variations among basins and differences between mountain and valley floor settings are obscured by the average ecoregion subarea values shown in Figure III.6-7. Detailed basin scale studies will be required for all projects planning to utilize groundwater as a water supply; these studies must identify and quantify the relationships between rainfall and significant components of groundwater recharge. Numerous previous investigations have used different methods and approaches to quantify the relationships between rainfall and estimated groundwater recharge in these desert environments (e.g., Avon and Durbin [1994], Dettinger, [1989], Hevesi and others [2003], and Maxey Eakin [1950], to cite just a few).

The quantity of recharge in a basin is one factor influencing a basin's capacity to support consumptive groundwater use on a sustainable, long-term basis. Natural discharge quantities (e.g., playas, springs, streams, and shallow-groundwater areas that support vegetation) also influence a basin's capacity to support long-term consumptive groundwater use.

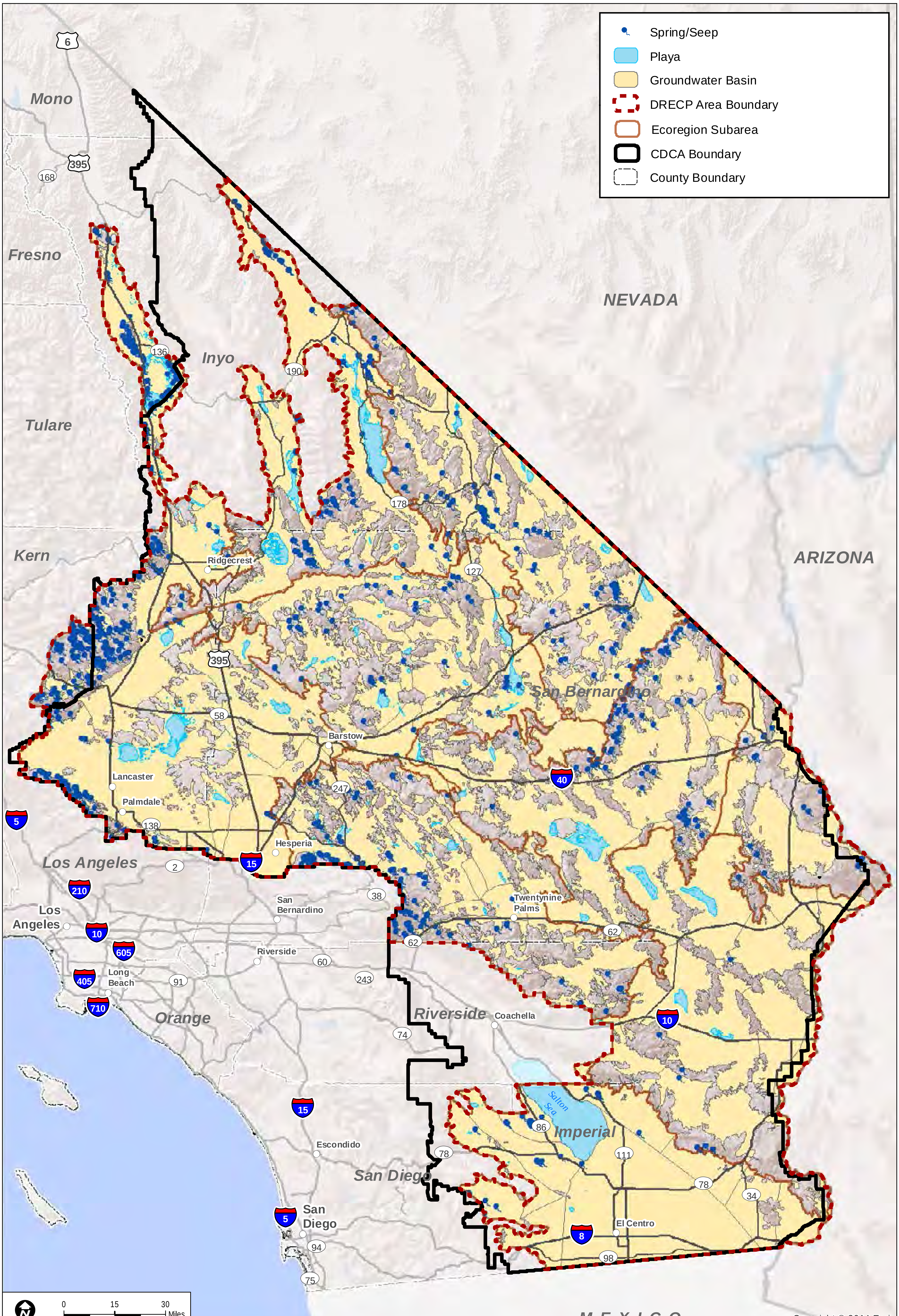
III.6.3.3.3 Discharge from Playas, Springs, Streams, and Shallow-Groundwater Areas

Groundwater can support vegetation or aquatic habitat where it discharges into playas, springs or streams, or where the water table is close enough to the land surface for plant roots to reach it. Detailed basin-scale studies are needed to identify and quantify the most significant components of groundwater discharge. The National Hydrography Dataset (NHD) represents the regional drainage network, and was used to map springs and playas in the DRECP area (Figure III 6-8). Following is a general assessment of these features, based on available regional scale information.

DRECP area basins containing playas appear in Figure III.6-8. Not all playas receive groundwater—for example, playas are also formed by the temporary ponding of runoff during significant mountain storm events. A reconnaissance-level survey of playa areas for groundwater discharge or shallow water-table conditions was therefore completed using aerial photo inspection (Google Earth). Photographs of all playas in the DRECP area were inspected, but the mapping method was ultimately only approximate. For example, if DWR Bulletin 118 reported groundwater flow toward the playa, if open water was visible in the playa, or if denser or greener vegetation appeared around the shore of the playa, it was assumed that the playa receives groundwater. The results indicated the likely existence of groundwater-dependent habitats potentially sensitive to the effects of increased groundwater withdrawals within the DRECP area. However, since the reconnaissance was regional and not exhaustive in scope, basin scale investigations are required to confirm and quantify these conditions, relative to specific project assessments.

Springs are common in the DRECP area (Figure III.6-8), and most springs are found either in the mountain canyons between basins (mountain block springs) or in upper piedmont areas where mountain bedrock transitions into alluvial valley fill (mountain front springs). In the north-central portion of the DRECP area, one inventory of springs in the 2,500-square-mile Mojave National Preserve listed a total of 240 springs (Shepherd 1993). A comparison of that list against both USGS topographic maps and springs listed in the Colorado RWQCB Basin Plan confirm that most of the springs are in upland terrain. If the average density of springs in the Mojave National Preserve is typical of ridges and valleys in the Basin and Range Province, the total number of springs in the 35,300-square-mile DRECP area could be on the order of 3,400. Most of these inferred springs would presumably also be in the upland areas.

Mountain block springs generally appear together with localized flow systems, and are sustained from above by groundwater that percolates down through bedrock fractures in mountain blocks. Therefore, mountain block springs are generally hydraulically disconnected from valley fill aquifers. In contrast, mountain front springs are generally connected to valley fill aquifers. Evaluations of the effects of groundwater pumping from beneath the valley floor on mountain front springs must consider both the permeability contrasts between the mountain front transition zones where the springs are located, and the relatively less permeable valley floor alluvium where the pumping occurs.



Sources: ESRI (2014); National Hydrography Dataset

FIGURE III.6-8

Springs, Seeps, and Playas

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Springs or shallow groundwater in valley floor areas are usually, but not always, associated with faults or narrow gaps between mountain blocks. Faults are abundant in the DRECP area, and many control groundwater flow (see Figure III.6-3). Wells on either side of faults sometimes have large differences in water levels. If permeability across a fault is sufficiently low, or if recharge is sufficiently high on the up-gradient side, the up-gradient groundwater levels can rise to the land surface and form springs that allow water to cross the fault as surface flow and support relatively thick stands of phreatophytes. The discharge typically percolates rapidly back into the ground on a fault's down-gradient side. Examples of these fault-induced springs are found in the Death Valley–Furnace Creek Fault Zone, the Surprise Spring Fault in the Deadman Valley Basin, and the San Andreas Fault in the Upper Santa Ana (Cajon) Basin. These alluvial groundwater basin springs can be vulnerable to groundwater pumping. For example, Surprise Spring, located in the Pahrump Valley basin, stopped flowing soon after pumping began in 1953, and all the mesquite trees dependent upon the spring died by 1985 (Londquist and Martin 1991). Springs supported by the regional carbonate aquifer in the northeastern part of the DRECP area can even be affected by pumping in adjacent basins. For example, springs along the eastern edge of the Death Valley basin could potentially be affected by pumping in the Middle Amargosa Valley or Greenwater Valley basins. Past pumping in the Nevada Portion of the basin may have reduced flow from springs in the Middle Amargosa Basin (Andy Zdon and Associates 2014).

There are two examples along the Mojave River of shallow groundwater discharge-supported stream flow caused by narrowing of the alluvial cross-sectional area where it passes between two mountain blocks. At the "narrows" near Victorville, riparian vegetation lines the river channel and pools and there are intermittent flows along a 6-mile reach where alluvial narrowing and less permeable bedrock forces the water table up to the ground surface. Shallow groundwater supports phreatophytic vegetation as far as 0.5 mile from the channel. The river flows through a more pronounced bedrock gap area of thin alluvium at Afton Canyon (the downstream end of the Lower Mojave River Valley Basin). Riparian vegetation and persistent flow along this 4-mile reach of the river, because of steep terrain on either side, support phreatophytic vegetation for only 0.2 mile at its widest point.

Shallow groundwater can support phreatophytic vegetation even if the water table does not intersect the ground surface to create surface flow. This appears to be the case at some playas classified as "discharging playas," where denser and darker vegetation is visible in aerial photos but open water is not. Facultative phreatophytes such as mesquite have tap roots that can extend more than 100 feet below the ground surface. The growth habit reflects the depth to the water table—a taller, denser canopy, with a greater proportion of aboveground biomass, develops where the water table is shallow.

III.6.3.3.4 Interconnected Basins and Subsurface Flow

Some groundwater basins are hydrologically connected where water is exchanged between the basins as subsurface flow. This means that changes in water inflow or outflow in one basin can potentially affect groundwater levels and storage conditions in adjacent basins. Three types of conditions allow groundwater flow between basins:

- **Alluvium is continuous between basins through a gap in bedrock.** Alluvium-filled gaps in the mountain ranges can allow groundwater to flow between basins. Examples include flow from the Middle Mojave River Valley Basin to the Harper Lake Valley Basin, from Lavic Valley to Broadwell Valley to Bristol Lake Basin, and from Pilot Knob to Brown Mountain Valley to Panamint Valley Basin.
- **Groundwater leaks across a fault boundary.** Many basins are bounded by relatively low permeability faults that obstruct groundwater flow and create large water-level differences across the fault. These faults are not always completely impervious, however, and regional gradients suggest they transmit some groundwater. Examples include the Pinto Mountain and Mesquite faults separating the Joshua Tree, Twentynine Palms and Dale Valley basins; the San Andreas Fault that separates the Ogilby Valley and Amos Valley basins from the Imperial Valley Basin; and the Coyote Creek–Superstition Mountain Fault that forms the boundary between the Borrego Valley and Ocotillo–Clark Valley basins.
- **Groundwater flows through regionally extensive limestone formations.** Exposed limestone formations in mountain ranges can be bedrock beneath lower elevation alluvial basins. Where the formations underlie the alluvium, they transmit groundwater beneath and between the overlying alluvial basins. Examples include groundwater flow from the Pahrump Valley and Spring Mountains in Nevada to the Middle Amargosa River Valley Basin, the Greenwater Valley and Middle Amargosa Valley basins to springs along the east side of Death Valley Basin, and springs in the San Bernardino Mountains.

Figure III.6-9 groups the DRECP area basins that DWR Bulletin 118 indicates are interconnected. There are other basins where flow between adjacent basins is likely, but where available geologic information and water-level data are insufficient to confirm existence of the flow. So even though available data do indicate that flow between basins is relatively common, it remains difficult to verify or quantify. Proposed renewable energy development applicants and existing grant holders will need to either collect or fund the collection of information so that the flow between interconnected basins can be adequately assessed and the effects of groundwater extraction on down-gradient conditions quantified.